

ITEA Live, Virtual, Constructive Conference Paper

“Recommendations Regarding Initial Guidelines for the Minimum Requirements Necessary for System Representations Used in the Joint Mission Environment (JME¹)”

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Executive Summary

Initial guidelines for minimum requirements for system representations need to include standardized, disciplined, system engineering methods and processes. The Capability Test Methodology (CTM)² describes methods and processes for development of a Joint Operational Context for Test (JOC-T) based upon authoritative sources and leveraging Department of Defense (DOD) Architecture Framework (DODAF) artifacts. These artifacts evolve through a systems engineering process that represents systems in logical and physical designs. Regardless of the specific composition of the design or the collection of required artifacts, system engineering principles, methods and processes are vitally important. The JOC-T needs to have sufficient detail to enable a comparison with the developed live, virtual, constructive distributed environment (LVC-DE) to satisfy user validation. System representations should be compatible with existing or future infrastructure and should maintain a consistent interface throughout the development cycle. Candidate systems representation requirements will include adequate documentation covering interoperability, compatibility, security based upon DOD Information Assurance Certification and Accreditation Process (DIACAP) and Verification, Validation and Accreditation (VV&A).

The JOC-T is validated by comparison to the referent authoritative sources (e.g., Joint Capabilities Integration and Development System [JCIDS], Joint Operations Concept [JOpsC] family, Analytic Agenda, concept of operations [CONOPS] documents, joint capability areas [JCA], Universal Joint Task Lists [UJTL], etc.). The fidelity of the eventual LVC-DE should be correlated to the evaluation strategy so as to tailor system representations to meet test and user validation requirements.

- Recommended Guidelines - LVC system representations should:
 - Be compatible with the current (or planned) network infrastructure.
 - Provide documentation on the following:

¹ The JME is an instantiation of the Joint Operational Context for Test (JOC-T) using the Live, Virtual, Constructive Distributed Environment capability. A joint mission environment is achieved when all required aspects of the JOC-T are present or accurately represented (live, virtual, or constructive).

² The CTM provides guidance on designing and executing system of systems tests in the JME to produce high quality capability assessments and evaluations supporting Department of Defense development and investment decisions. CTM can involve developmental or operational testing during multiple phases of the acquisition lifecycle, including concept refinement, technology development, and system development.

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- Interoperability standards, problems and issues; system compatibility with infrastructure requirements (Distributed Interactive Simulation [DIS], high level architecture [HLA], test and training enabling architecture [TENA], etc.)
- VVA
- Security based upon DIACAP
- Be able to generate and/or accommodate the required data elements necessary to satisfy evaluation measurements (including instrumentation and tools).
- Be based upon a JOC-T derived from authoritative sources and using standardized, disciplined system engineering methods, processes and products (e.g., DODAF artifacts).
- Provide quantitative fidelity descriptions if the representation must produce critical parameters to specified levels of accuracy and precision.
- Use comparison to similar accredited simulations as a basis for defining the fidelity aspects of representational requirements.
- Limit the fidelity required and implemented to what is actually needed for user validation and evaluation requirements.

Recommendations Regarding Initial Guidelines for the Minimum Requirements Necessary for System Representations Used in the Joint Mission Environment (JME)

Testing in a Joint Environment Roadmap

The Testing in a Joint Environment Roadmap, Final Report, Annex B discussed overarching requirements for system representations:

Constructive and virtual representations of acquisition systems must be developed to be compatible with the joint mission infrastructure architecture. . . . Most importantly, it should be realized that a system's interface should be consistent throughout all these acquisition phases, regardless of whether it is a live, virtual, or constructive representative. . . . [in addition] it will be necessary to establish a comprehensive, yet efficient, accreditation process to ensure that existing capabilities are adequate for joint force assessments. Accreditation of individual models, as well as accreditation of the interactions required of those models, will be necessary.³

- Recommended Guideline: Constructive and virtual system representations should be compatible with the current (or planned) network infrastructure.

DOD Acquisition Planning and the CTM

The DOD uses a capability-based planning (CBP) process as the principal decision support process for transforming the military forces to support the national military strategy and the defense strategy. JCIDS is one component of the CBP process. JCIDS plays a key role in identifying the capabilities required by the warfighters to support the National Defense Strategy and the National Military Strategy, but successful delivery of those capabilities relies on the JCIDS process working in concert with the other joint and DOD decision processes encapsulated in CBP. Documentation developed (such as joint capabilities document [JCD], initial capabilities document [ICD], capability development document [CDD], capability production document [CPD], and joint doctrine, organization, training, materiel, leadership and education, personnel, and facilities [DOTMLPF] change recommendation [DCR]) during the JCIDS process provides the formal communication of capability gaps between operators and the acquisition, test and evaluation, and resource management communities. These documents provide the integrated architecture products that ensure understanding of the linkages between capabilities and systems and aid acquisition decision-making; and their performance attributes, including key performance parameters (KPP) and key system attributes (KSA) that define the most critical elements of performance for the systems under development.⁴ Implementation of the CTM leverages these JCIDS-derived products and attributes to define the capability to be evaluated, and to develop a realistic JME in which to test. During CTM processes the systems, components, equipment, data, and other items that will compose the system of systems (SoS) are summarized; and the capability to be evaluated

³ Director, Operational Test & Evaluation, "Testing in a Joint Environment Roadmap, Strategic Planning Guidance, Fiscal Years 2006-2011, Final Report," November 12, 2004, B-9.

⁴ CJCSI 3170.01F, Joint Capabilities Integration and Development System, Enclosure A, 1 May 2007.

is explained. This results in an initial description of the mission objectives and details the high-level mission concept.

Determining what systems are needed for the joint mission or task is the first order of business in the CTM process. DOD defines a capability as the ability to achieve a desired effect under specified standards and conditions through combinations of ways and means to perform a set of tasks. It is defined by an operational user and expressed in broad operational terms. Available system capability documents should provide the SoS description. The appropriate document used for this description will depend upon whether the capability to be evaluated is a materiel or a non-materiel solution, and the maturity of the system/SoS development process. The system documents provide an overview of the capability gap in terms of the relevant range of military operations and the timeframe under consideration. They also explain the capability the system/SoS delivers and how it relates to the key characteristics identified in the JOpsC and applicable CONOPS, and provide integrated architectures. The JCAs, analytical baselines, and UJTLs provide context and references for the system/SoS. The capability/SoS description summarizes the systems, components, equipment, and data that will compose the SoS, and details how the SoS contributes to the required capability, the operating environment of the SoS, how the capability will be employed on the battlefield, and where it will be employed. The initial system/SoS descriptions provide the key features and subsystems, hardware, and software for each increment's configuration. By definition, a "system of systems (SoS)" is "A set or arrangement of interdependent systems that are related or connected to provide a given capability. The loss of any part of the system will significantly degrade the performance or capabilities of the whole."⁵ Thus to fully describe the capability, the SoS must be decomposed into testable systems that can be integrated into the JME.

In addition to the System Engineering processes, the CTM develops an Evaluation Strategy based upon three levels of measurements: 1) measure of system/SoS attributes (MOSA); 2) task measures of performance (TMOP); and 3) mission measures of effectiveness (MMOE). This measures framework supports resolution of critical operational issues (COIs). This measures framework produces a number of products including an Integrated Data Requirements List (IDRL). System representations need to be able to generate and/or accommodate the required data elements to satisfy the IDRL.

- Recommended Guideline: Provide documentation on the following:
 - Interoperability standards, problems and issues; system compatibility with infrastructure requirements (DIS, HLA, TENA, etc.)
 - VV&A
 - Security based upon DIACAP
- Recommended Guideline: System representations need to be able to generate and/or accommodate the required data elements necessary to satisfy evaluation measurements (including instrumentation and tools).

⁵ CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development System, Glossary, Part II - Definitions, 1 May 2007.

The JOC-T Development Process

The JOC-T describes the overall philosophy of forces operating jointly and the tactics, techniques, and procedures (TTP) to be employed to achieve effects on the battlefield by exhibiting capabilities they will not possess separately. Developing the JOC-T includes performing operational analyses to constrain the test into a manageable set of systems and operational interactions. It is derived from the JME in which the system/SoS is designed to operate and provides the mission statement, end states, mission objectives, blue forces, threat, and environmental aspects which provide a foundation for the test scope. This composition allows for VV&A of the JOC-T by checking for consistency across interaction descriptions, and identifying operational context gaps through traceability analyses back to authoritative sources and test customer capability evaluation needs. The focus on JOC-T ensures the testing will focus on the overall structure, major elements, and objectives of the test and evaluation (T&E) program with relation to the operational context. The JOC-T can then be used in follow-on development of the test scenario, vignettes, and trials. The processes involved in creating the JOC-T are shown in figure 1.

DOD Architecture Framework Artifacts in the JOC-T

The JOC-T document includes several operational and system views. The OV-1 is a high level mission graphic that portrays key joint capability effects to include the mission statement, end state, the key blue and threat forces as well as specified tasks. The blue operational activity model (blue operational view-5, [BOV-5]) describes the activities through which each military mission is accomplished. The blue operational node connectivity description

(BOV-2) identifies the operational nodes and information flow lines between the blue forces. The blue organizational relationships chart (BOV-4) should also be included in order to show the task organization of the blue forces. This is vital to understanding the relationships among the organizations which comprise the blue force. The blue SoS interface description is captured in the blue systems view (BSV-1) which graphically illustrates data elements and data characteristics and the relationships among them. The blue operational activity to systems functionality traceability matrix (BSV-5) shows the SoS operational activity to SoS function traceability matrix; this depicts the mapping between the capabilities and systems and identifies the transition of a capability into a planned or fielded system. The systems

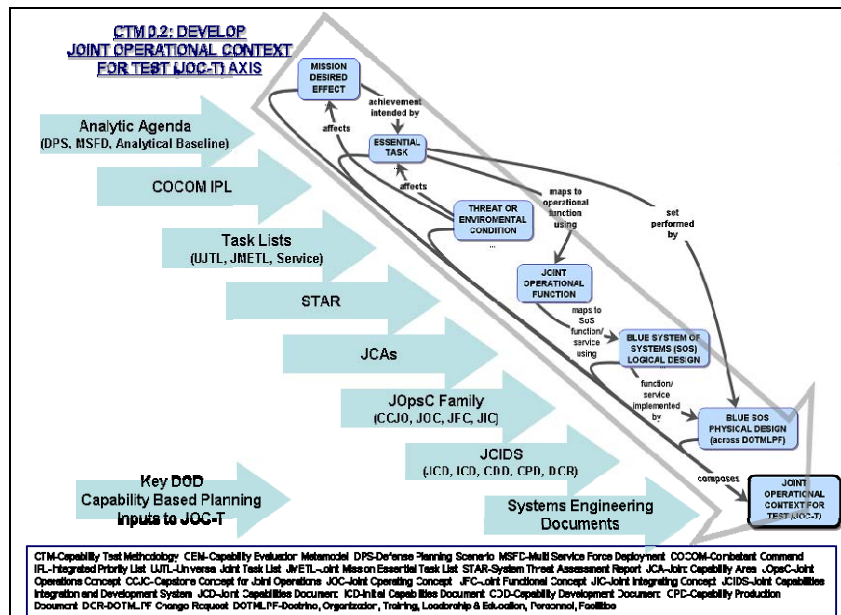


Figure 1. Joint Operational Context for Test Development

functionality description (BSV-4) describes the system functions as well as the data produced and consumed; it describes the how, what, and the relationships between the blue forces. The final systems view is the BSV-6, which contains the details on the architecture's systems data elements and their attributes grouped under the title Data Exchange. The systems data exchange matrix provides the systems details that implement the operational information exchange requirements and relates these data elements to systems nodes, system functions (contained in the SV-4) and time. In most cases the JCIDS architectural product directly translates into the CTM blue architectural product. At other times (depending upon the system development maturity), some data/information may need to be collected from the applicable JCIDS documents and the DODAF products updated or modified to produce the corresponding blue product.

Environmental Factors

By completing the operational and systems views the tester is able to determine the blue actions, the sequence diagrams and phasing of maneuver, the interactions, and the environment effects. In order to fully understand the SoS, it is necessary to describe the context in which the SoS will be employed. The operational environment addresses all operational requirements and specifications required of the SoS to include the individual system platforms. It establishes the geographical and environmental conditions in which the SoS will operate. Different operating environments and their characteristics will affect support requirements.

When describing the environment in which the SoS will operate, it is important to discuss both the physical and civil environmental aspects. The environment includes the air, water, land, plants, animals, and other living organisms, manmade structures, historical and cultural resources, and the interrelationships that exist among them.⁶ Analysis of the environment involves examining environmental conditions that are potential test and evaluation factors, and should be identified as input into the development of the evaluation strategy. Environmental conditions are broken down as either physical or civil.

The physical environment includes both natural and man-made environments, and could extend to geospatial, meteorological, oceanographic, and space. Physical environment can include both external and internal conditions (such as temperature, humidity, radiation, magnetic and electric fields, and shock vibration). SoS environment descriptions should include SoS influences that would affect the performance, reliability, or survivability of the SoS. If key to the testing of the SoS, the physical environment description should include possible modes of transportation into and within expected areas of operation and existing infrastructure support capabilities.

Civil conditions include local indigenous customs, economic, ethnic, political and religious factions or groups, group history and inter-relationships, general population views toward blue and threat forces, etc.

⁶ CJCSM 3170.01C, Operation of the Joint Capabilities Integration and Development System, Glossary, Part II - Definitions, 1 May 2007.

Threat Representations

The final portion of the JOC-T is the threat force description. Specifically, it contains the recommended threat operational views (TOV) to be created. The system/SoS threat assessment should include threat force descriptions. These descriptive products can include a threat order of battle, threat system/SoS descriptions (functional and physical threat system views), threat command and control (C2) structure operational node connectivity description view (TOV-2), threat actions operational activity model (TOV-5), threat maneuver scheme/phasing, threat force lay downs, and threat interactions. The TOV-1, TOV-4, and TOV-5 are used to show the organizational relationship, the C2 structure, and the SoS interface and functionality. The description of the threat forces should include the interactions of the threat with blue forces, with other threat forces, and with the environment.

Threat actions include joint/Service task decompositions, mission threads, and threat operational activity flows. Descriptions include key blue to threat, threat to threat, and threat to environment interactions with potential testing implications. The threat high-level graphic should focus on the threat aspects for the SoS. The Threat Force OV-1 describes a mission and the main operational nodes. It should depict any unique aspects of threat force operations as well as the interactions between threat forces, their architecture, and the environment. The purpose of the OV-1 is to give a high-level description of what the threat forces are supposed to do and explain how this will be achieved. The textual portion of the OV-1 should explain the top-level operational role of the threat forces shown in the graphic and the context within which they are performing their mission.

- Recommended Guideline: System representation requirements should be based upon a JOC-T derived from authoritative sources and using standardized, disciplined system engineering methods, processes and products (e.g., DODAF artifacts).

VVA of the LVC-DE

The validation of the JOC-T uses the aforementioned authoritative sources as referent.⁷ The LVC is then validated against the JOC-T as referent. The key notion here is the “test” part of the JOC-T; this means the JOC-T represents a specific scope, resolution, and context for LVC development needed for test.

Scope is concerned with the range of parameters or applications of concern for the referent.

Resolution is concerned with the level at which distinctions can be made in the information of the referent. . . .Resolution of information in the referent must be at the lowest level required to support M&S validation assessment.

Context addresses the environment within which the referent information is applicable. Sometimes the context is simply a set of assumptions; sometimes the context is a physical condition (such as pressure). There is a difference between

⁷ “The referent is the best or most appropriate codified body of information available that describes characteristics and behavior of the reality represented in the simulation from the perspective of validation assessment for intended use of the simulation.” Pace, D.K. “The Referent Study Final Report,” Defense Modeling & Simulation Organization, June 2004, p. 6.

context and scope. Context is not specified in the variables used to represent entities, processes, and interactions described by the information in the referent, but is concerned with parameters and factors that might influence the measurements (values) of the referent information.⁸

Using the JOC-T as referent, the LVC seeks to achieve a level of fidelity that will meet the user requirements for validation. In order to meet these requirements, the “. . . referent must be carefully defined in terms of how much is to be simulated (i.e., entities and characteristics) and what interactions are involved (i.e., relationships between entities in the referent).”⁹ The JOC-T development process is intended to satisfy this fidelity measurement requirement.

Required fidelity will vary depending on the evaluation focus. If the representation must produce critical parameters to specified levels of accuracy and precision, then system representations should provide quantitative fidelity descriptions.¹⁰ Figure 2 shows a framework for understanding and applying fidelity; it “. . . clarifies the difference between the fidelity required by the application (captured in the simulation requirement), and the fidelity present in a specific model or simulation (contained with the M&S capabilities). Both the fidelity required and the fidelity present is characterized in terms of resolution, error/accuracy, sensitivity, precision and capacity.”¹¹

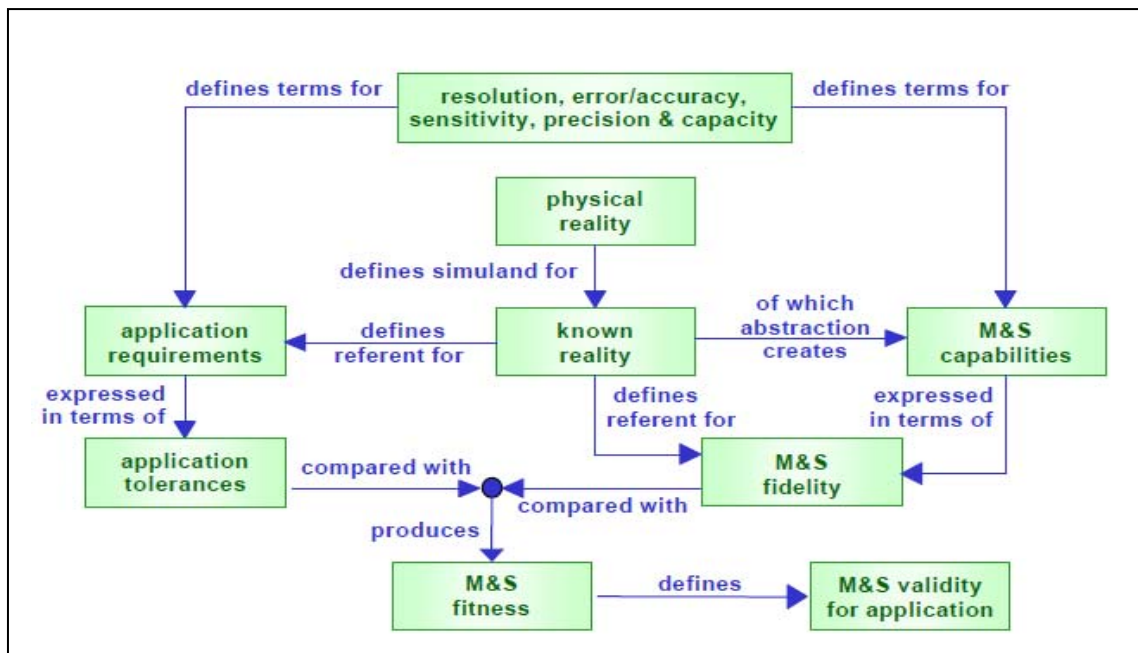


Figure 2. Framework for Understanding and Applying Fidelity

Fidelity descriptions that use quantitative data fall into the category of “long descriptions.”

Long descriptions of simulation fidelity typically describe simulation fidelity in terms of multiple explicit attributes. The number and kinds of attributes considered

⁸ Ibid., p. 14.

⁹ Defense Modeling & Simulation Office, “Recommended Practices Guide Special Topic: Fidelity,” 2000. p. 6.

¹⁰ Ibid., p. 5.

¹¹ Ibid., p. 7-9.

varies with the construct being employed for simulation fidelity. Most constructs consider either the scope of the simulation's treatment of significant factors in the application domain (this usually involves some kind of *enumeration*), the quality of treatment of factors within the simulation (as indicated by parameter accuracy, resolution, etc.), or both.¹²

In figure 2, the M&S fidelity description is compared to the application tolerances (coming from the JOC-T and the evaluation strategy) to render a “fitness” of the representation in the JME. The evaluation strategy is key to whether or not a representation is live, virtual or constructive. The resolution, error/accuracy, sensitivity, precision and capacity that are required to satisfy the measurements in the evaluation strategy will dictate the choices of fidelity made in LVC development. Further decisions based upon cost and schedule will translate into the degree of risk accepted by the program manager/tester. It is useful to compare the representation to simulations meeting similar purposes in order to gauge its fitness for purpose.¹³

- Recommended Guideline: If the representation must produce critical parameters to specified levels of accuracy and precision, then system representations should provide quantitative fidelity descriptions.
- Recommended Guideline: Use comparison to similar accredited simulations as a basis for defining the fidelity aspects of representational requirements.¹⁴
- Recommended Guideline: System representations should limit the fidelity required and implemented to that which is actually needed for user validation and evaluation requirements.¹⁵

¹² Ibid., p. 4.

¹³ Ibid., p. 10.

¹⁴ Ibid.

¹⁵ Ibid.



Joint Test & Evaluation Methodology (JTEM) Joint Test & Evaluation (JT&E)

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Recommended Guidelines



Live, virtual, constructive (LVC) system representations should:

1. Be compatible with the current (or planned) network infrastructure
2. Be based upon a JOC-T derived from authoritative sources and using standardized, disciplined, system engineering methods
3. Provide documentation on Interoperability, VV&A and DIACAP
4. Be able to generate and/or accommodate required data elements necessary to satisfy evaluation measurements
5. Provide quantitative fidelity descriptions if the representation must produce critical parameters to specified levels of accuracy
6. Use comparison to similar accredited simulations as a basis for defining the fidelity aspects of representational requirements
7. Limit the fidelity required and implemented to that which is actually needed for user validation and evaluation requirements



Testing In a Joint Environment Roadmap (TIJR)



1. Be compatible with the current (or planned) network infrastructure

- TIJR discussed overarching requirements for system representations:

“Constructive and virtual representations of acquisition systems must be developed to be compatible with the joint mission infrastructure architecture....Most importantly, it should be realized that a system’s interface should be consistent throughout all these acquisition phases, regardless of whether it is a live, virtual, or constructive representative...”

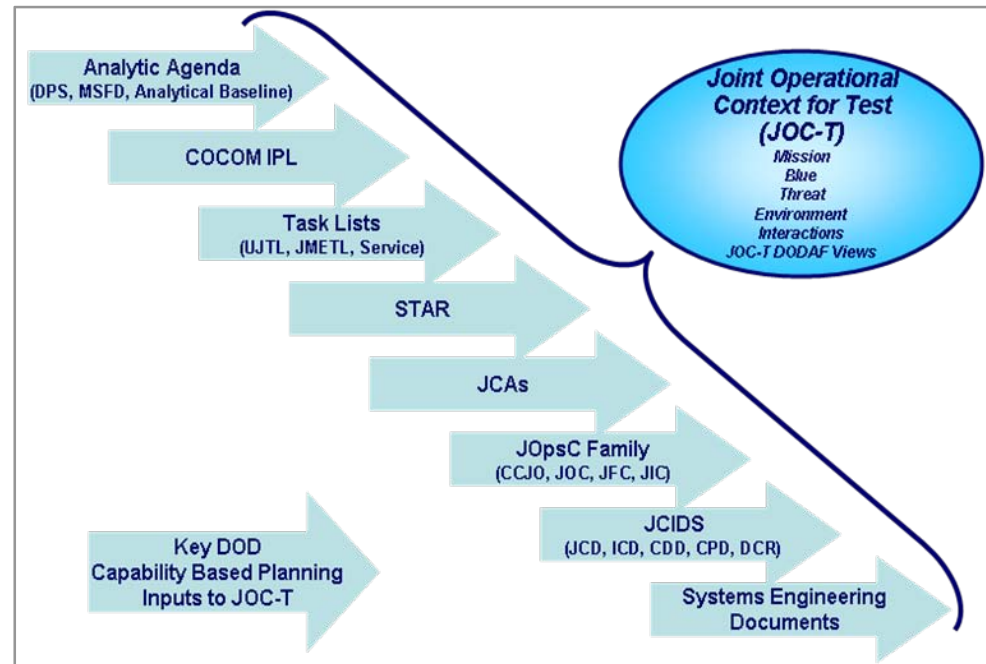


Joint Operational Context for Test (JOC-T)



2. Be based upon a JOC-T derived from authoritative sources and using standardized, disciplined, system engineering methods

- Blue Forces
- Threat Forces
- Environment (Physical & Civil)
- Conceptual Model
- Logical Design
- Physical Design
- DODAF Artifacts

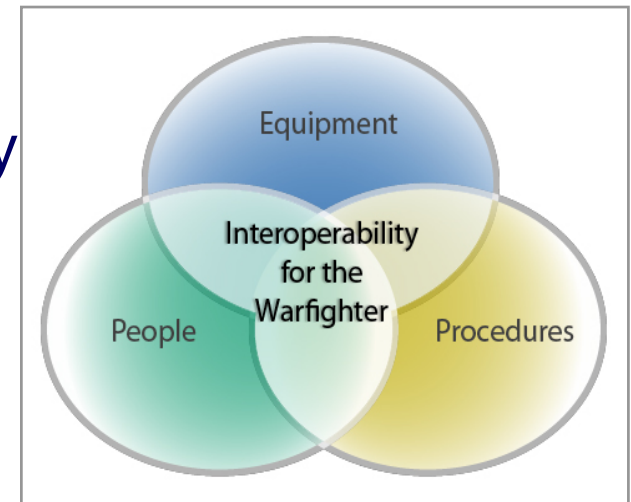




Documentation

3. Provide documentation on Interoperability, VV&A, and DIACAP

- Interoperability standards, problems and issues; compatibility with infrastructure requirements (DIS, HLA, TENA, etc.)
- System VV&A reduces the risk to overall LVC-DE validation
- DIACAP requirements can be a “long pole” in the tent (JBD2 lesson learned)

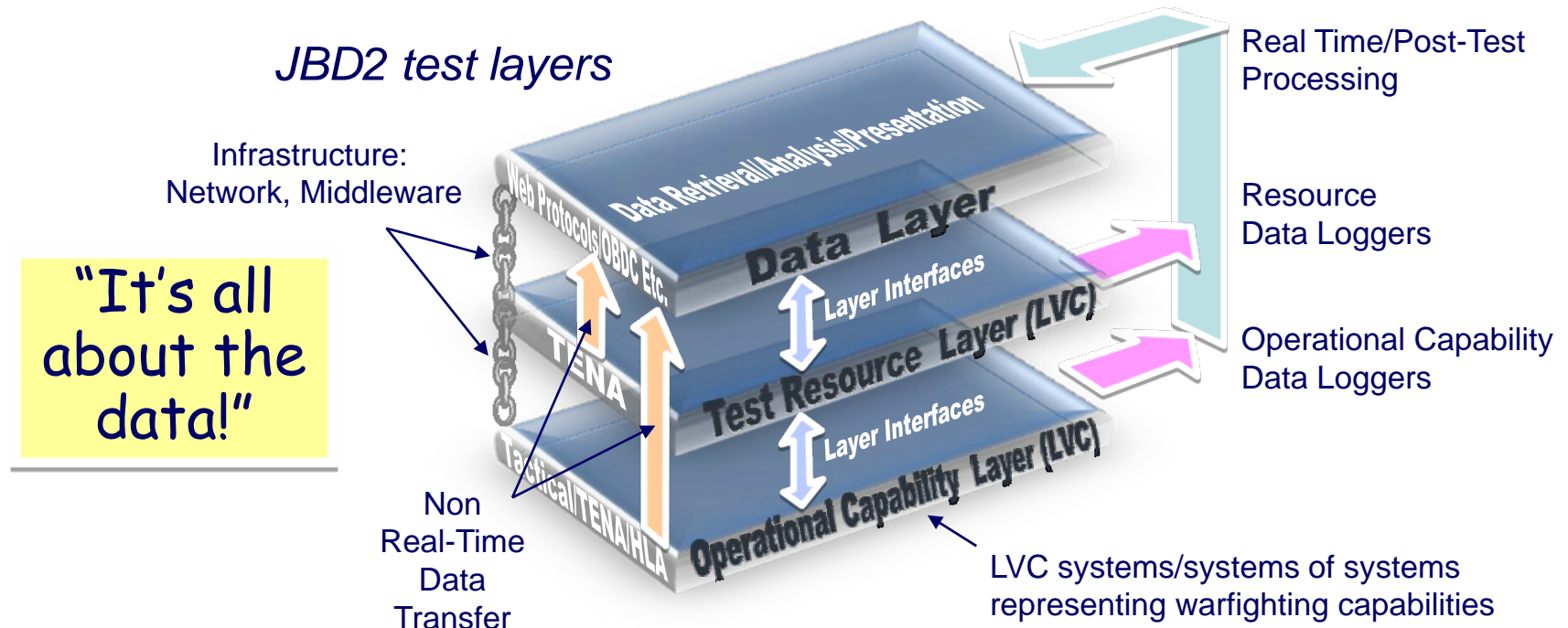


Important inputs for successful instantiation of the LVC-DE



Data Collection

4. Be able to generate and/or accommodate required data elements necessary to satisfy evaluation measurements





Fidelity Description

5. Provide quantitative fidelity descriptions if the representation must produce critical parameters to specified levels of accuracy
- Qualitative (High/Medium/Low) descriptions lack the information content necessary to support technical decisions about simulation fitness for a particular purpose
 - Fidelity characterized in terms of resolution, error/accuracy, sensitivity, precision and capacity



Comparison



6. Use comparison to similar accredited simulations as a basis for defining the fidelity aspects of representational requirements
- In the absence of quantitative methods, the fidelity of the proposed simulation can be compared to simulations meeting similar purposes in order to gauge its fitness for purpose
 - Leverage systems/simulations that have completed verification, validation, and accreditation (VV&A) if the similarity is sufficient



Fidelity Threshold

7. Limit the fidelity required and implemented to that which is actually needed for user validation and evaluation requirements
 - Using the Joint Operational Context for Test (JOC-T), the LVC seeks to achieve a level of fidelity required by the evaluation focus that will meet the user requirements for validation
 - Higher fidelity simulations cost more time and money to build, more verification and validation (V&V), and more to operate
 - Real value of system representations comes from abstracting away irrelevant details

Avoid “Gold-Plating”



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Serving the testing, acquisition, and warfighting communities



Back-up

Framework for understanding and applying fidelity

